BAKER BOTTS LLP

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35.U.S.C. 371

EXPRESS MAIL LABEL No	DATE
EU206387433US	28 MARCH 2002

ATTORNEY'S DOCKET NO. A35109 PCT USA

U S APPLICATION NO 10/089479

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/KR00/00935	21 AUGUST 2000	30 SEPTEMBER 1999

TITLE OF INVENTION APPARATUS AND METHOD FOR FORMING SINGLE CRYSTALLINE NITRADE SUBSTRATE USING HYDRIDE VAPOR PHASE EPITAXY AND LASER BEAM

APPLICANT(S) FOR DO/EO/US Bong-Cheol Kim

Applicant herewith submits to the United States Designated /Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
3. ☑ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(I).
4. ☑ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☑ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☑ A copy of the International Search Report (PCT/ISA/210)
   a. ☑ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☑ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☑ A copy of the International Preliminary Examination Report (PCT/IPEA/409)
12. ☑ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☑ A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. ☑ Other items or information:
    a. ☑ a copy of the International Search Report (PCT/ISA/210)
    b. ☑ a copy of the International Preliminary Examination Report (PCT/IPEA/409)

Other:
Specification (10 pages), claims (3 pages) and 1 page abstract
3 sheets formal drawings
WO 01/23648 International Publication
PCT Request

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17. ✔ The following fees are submitted:

CALCULATIONS PTO USE ONLY

Basic National Fee (37 CFR 1.492(a)(1)-(5):

Neither international preliminary examination fee (37 CFR 1.482)
Nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO (1.492(a)(3)) $1,040

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO (1.492(a)(5) $890.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO(1.492(a)(2)) $740.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) (1.492(a)(1)) $710.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $ 100.00

ENTER APPROPRIATE BASIC FEE AMOUNT			=	$ 1,040	
Surcharge of $130.00 for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 C.F.R. 1.492)(e)).				$	
Claims	**Number Filed**	**Number Extra**	**Rate**	$	
Total Claims	12 -20=	0	X $ 18.00	$ 0	
Independent Claims	2 -3=	0	X $ 84.00	$ 0	
Multiple dependent claim(s) (if applicable)			+ $280.00	$	
TOTAL OF ABOVE CALCULATIONS			=	$ 1,040	
Reduction by ½ for filing by small entity, if applicable.				$ 520	
SUBTOTAL			=	$ 520	
Processing fee of $130.00 for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).			+	$	
TOTAL NATIONAL FEE			=	$ 520	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property			+	$ 40	
TOTAL FEES ENCLOSED			=	$ 560	
				Amt. refunded	$
				charged	$

a. ✔ A check in the amount of $ 520 & 40 to cover the above fees is enclosed.

b. [ ] Please charge our Deposit Account No. 02-4377 in amount of $_____ to cover the above fees. A copy of this sheet is enclosed.

c. ✔ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-4377. A copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:
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30 Rockefeller Plaza
New York, New York 10112-4498

Attorney: James J. Maune PTO Reg: 26,946

28 MARCH 2002
Date

BAKER BOTTS L.L.P.

Attorney Docket Number: A35109 PCT USA

Title: APPARATUS AND METHOD FOR FORMING SINGLE CRYSTALLINE NITRADE SUBSTRATE USING HYDRIDE VAPOR PHASE EPITAXY AND LASER BEAM

Use Space Below for Additional Information:

BAKER BOTTS LLP

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APPLICANT(S) FOR DO/EO/US: Bong-Cheol Kim

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Use Space Below for Additional Information:

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Bong-Cheol Kim
Serial No.	:	To be Assigned
Filed	:	To be Assigned
For	:	APPARATUS AND METHOD FOR FORMING SINGLE CRYSTALLINE NITRIDE SUBSTRATE USING HYDRIDE VAPOR PHASE EPITAXY AND LASER BEAM

PRELIMINARY AMENDMENT

Assistant Commissioner of Patents

Washington, D.C. 20231

Sir:

Preliminary to the examination of the above-identified application, please make the following amendment to the claims:

In the Claims:

Cancel claims 1 to 12.

Add the following new claims:

13. An apparatus for forming a nitrogen compound semiconductor substrate, the apparatus comprising:

a reacting chamber for forming a single crystalline nitride film on a parent substrate;

a heating chamber connected to the reacting chamber within a processing channel, wherein the single crystalline nitride film is separated from the parent substrate by laser beam illumination at a higher temperature than a room temperature; and

a supporter for supporting the single crystalline nitride film and the parent substrate and maintaining the single crystalline nitride film in a predetermined temperature.

14. The apparatus as recited in claim 13, wherein the apparatus is a hydride vapor phase epitaxy apparatus.

15. The apparatus as recited in claim 13, wherein the predetermined temperature is in a range of 600 °C to 1000 °C.

16. The apparatus as recited in claim 13, wherein the apparatus further comprises an exhausting chamber positioned between the reacting chamber and the heating chamber, and wherein each of reacting, exhausting and heating chambers is isolated from each other by shutters.

17. A method for forming a nitrogen compound semiconductor substrate, the method comprising the steps of:

a) preparing a parent substrate;

b) forming a single crystalline nitride film on the parent substrate in a reacting chamber;

c) moving the parent substrate onto a heating chamber and maintaining the single crystalline nitride film in a predetermined temperature which is higher than a room temperature; and

d) illuminating laser beam on a backside of the parent substrate and separating the single crystalline nitride film from the parent substrate.

18. The method as recited in claim 17, further comprising the steps of:

e) heating the parent substrate up to a predetermined

temperature which is higher than a room temperature; and

f) moving onto a supporter the parent substrate on which the single crystalline nitride film is formed, wherein the supporter is positioned in a heating chamber which is connected to the reacting chamber within a processing channel.

19. The method as recited in claim 17, wherein the parent substrate is selected from one of sapphire (Al_2O_3), spinel ($MgAl_2O_4$) or silicon carbide (SiC).

20. The method as recited in claim 19, wherein the single crystalline nitride film is formed by a hydride vapor phase epitaxy.

21. The method as recited in claim 19, wherein the step b) comprises the steps of:

a1) positioning a material selected from a group III at a first temperature region of 600 °C to 900 °C in the reacting chamber and positioning the parent substrate at a second temperature region of 1000 °C to 1100 °C in the reacting chamber;

a2) injecting a nitrogen gas into the reacting chamber;

a3) injecting a hydrochloric acid gas into the reacting chamber; and

a4) injecting an ammonia gas into the reacting chamber.

22. The method as recited in claim 9, wherein the parent substrate is heated up to 600 °C to 1000 °C.

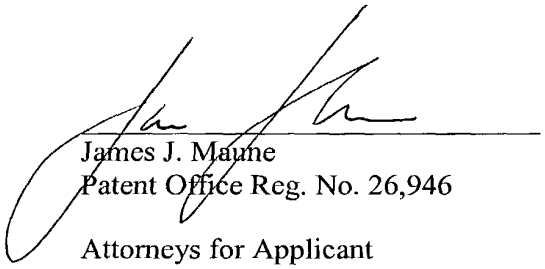
23. The apparatus as recited in claim 21, wherein the apparatus further comprises an exhausting chamber positioned between the reacting chamber and the heating chamber, and wherein each of the reacting, exhausting and heating chambers is isolated from each other by shutters.

24. The method as recited in claim 18, wherein the parent substrate is selected from one of sapphire ($A1_2O_3$), spinel ($MgA1_2O_4$) or silicon carbide (SiC).

REMARKS

This amendment eliminates multiple dependency in the claims and puts the claims in better U.S. format. No new matter is introduced by this amendment.

Respectfully submitted,



James J. Maune
Patent Office Reg. No. 26,946

Attorneys for Applicant
(212) 705-2566

Baker Botts L.L.P.
30 Rockefeller Plaza
New York NY 10112

3/pr1>

APPARATUS AND METHOD FOR FORMING SINGLE CRYSTALLINE NITRIDE SUBSTRATE USING HYDRIDE VAPOR PHASE EPITAXY AND LASER BEAM

Description

Technical Field

The present invention relates to an apparatus and a method for making a single crystalline nitride substrate; and, more particularly, to an apparatus and a method for preventing cracks from being generated in a single crystalline nitride substrate.

Background Art

A GaN single crystalline substrate, as an example of a single crystalline nitride substrate, will be described. Generally, the GaN materials has a melting point more than of 2400 ℃ and the dissociation pressure of nitride in the GaN materials is about ten thousand atm. Accordingly, this high melting point and high dissociation pressure make it impossible to create a large single crystalline GaN bulk using typical growing methods of the semiconductor crystals. A needle-shaped crystal growing method, in which a gallium gas directly reacts on an ammonia gas at a high temperature of about 1000 ℃ to 1150 ℃, and a plate-shaped crystal growing method, in which nitrogen is dissolved in liquid gallium at a

high temperature of about 1500 ℃ to 1600 ℃ and at a high nitrogen pressure corresponding to about 20000 atm, has been used to create a single crystalline GaN bulk (hereinafter, referred to as a GaN bulk).

However, these crystal growth methods have made a small-sized GaN bulk which has only a few millimeters in size and about 100 μm in thickness. Accordingly, it is impossible to achieve a commercial success in using the GaN bulk.

To solve the above problem, a hydride vapor phase epitaxy has been used to create the GaN bulk at a growing rate of 100 μm/hour. That is, after forming a thick GaN film on a parent substrate, such as sapphire or SiC substrate, the parent substrate is removed and then the GaN bulk is finally formed.

The removal of the parent substrate is carried out by the mechanical polishing method or laser beam. In particular to laser, as shown in Fig. 1, after forming the thick GaN film on the parent substrate at a high temperature of about 1000 ℃ to 1100 ℃, the thick GaN film on the parent substrate is cooled down to a room temperature. After increasing the temperature of the parent substrate up to about 600 ℃, the thick GaN film is separated from the parent substrate using laser beam in an additional apparatus different from the hydride vapor phase epitaxy ("Large free-standing GaN substrate by hydride vapor phase epitaxy and laser induced lift-off," by K. Kelly et al, Jpn. J. Appl. Phys. Vol. 38, No.

3A (pt 2), 1999).

In the above-mentioned hydride vapor phase epitaxy, since the thick GaN film is formed on the sapphire substrate at a high temperature and it is cooled down to the room temperature, cracks are generated by the lattice mismatch and thermal expansion coefficients between the GaN film and the sapphire substrate. Because of these cracks, the GaN bulk is restricted within a small-sized substrate and electric characteristics therein are also deteriorated.

Disclosure of Invention

It is, therefore, an object of the present invention to provide an apparatus and a method for preventing cracks from being generated in a single crystalline nitride substrate which is made by a hydride vapor phase epitaxy method.

Another object of the present invention is to provide an apparatus and a method for forming a large single crystalline nitride substrate on a commercial basis.

In accordance with an aspect of the present invention, there is provided an apparatus for forming a compound semiconductor substrate, the apparatus comprising: a reacting chamber for forming a single crystalline film on a parent substrate; a heating chamber connected to the reacting chamber within a processing channel, wherein the single crystalline film is separated from the parent substrate at a higher temperature than a room temperature; and a supporter for supporting the single crystalline film and the parent

substrate and maintaining the single crystalline film in a predetermined temperature.

In accordance with another aspect of the present invention, there is provided a method for forming a compound semiconductor substrate, the method comprising the steps of: a) preparing a parent substrate; b) forming a single crystalline film on the parent substrate in a reacting chamber; c) maintaining the single crystalline film in a predetermined temperature which is higher than a room temperature; and d) illuminating laser beam on a backside of the parent substrate and separating the single crystalline film from the parent substrate.

According to the present invention, a thick GaN film is formed on a parent substrate, such as sapphire (Al_2O_3), spinel ($MgAl_2O_4$) or silicon carbide (SiC), which has the lattice mismatch with the single crystalline GaN film and a different thermal expansion coefficient, and the parent substrate is heated up to a range of 600 ℃ to 1000 ℃. In this temperature range, the single crystalline GaN film is separated from the parent substrate by laser beam.

Brief Description of Drawings

The above and other objects and features of the present invention will become apparent from the following description of preferred embodiments taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a plot illustrating a temperature variation in

a conventional method for forming a single crystalline nitride substrate;

Fig. 2 is a plot illustrating a temperature variation in a method for forming a single crystalline nitride substrate according to the present invention;

Fig. 3 is a schematic cross-sectional view of an apparatus for forming a single crystalline nitride substrate according to the present invention; and

Figs. 4A to 4D are schematic cross-sectional views illustrating a method for forming a single crystalline nitride substrate according to the present invention.

Best Mode for Carrying out the Invention

Referring to Fig. 3, a horizontality-type hydride vapor phase epitaxy apparatus of an atmospheric pressure is shown in order to form a single crystalline nitride substrate. The hydride vapor phase epitaxy apparatus includes a reacting chamber 11A in which a quartz boat (not shown) is placed, a heating chamber 11C having a supporter 40 to maintain a specimen, and an exhausting chamber 11B positioned between the reacting chamber 11A and the heating chamber 11C and coupled to an exhausting system 16. The temperature of the supporter 40 in the heating chamber 11C is maintained in a specific temperature range and laser beam illumination to separate a single crystalline nitride film from a parent substrate 30 is carried out in the heating chamber 11C. Further, each of the chambers 11A to 11C adjacent to the exhausting chamber 11B is

sealed up with shutters 12 and flanges 12A are mounted on both ends of the chambers 11A and 11C.

The reacting chamber 11A is surrounded by a multi-step electric furnace 13 and is connected to a first inlet to supply an ammonia gas and a second inlet to supply hydrochloric acid and nitrogen gases. These gases react on Ga materials 20 within the reacting chamber 11A and then a thick GaN film is deposited on the parent substrate 30 adjacent to the Ga materials 20. While the thick GaN film is grown in the reacting chamber 11A, the reacting gases are purged away through the exhausting system 16 in the exhausting chamber 11B and when the growth of the single crystalline nitride substrate (the thick GaN film) has been finished, the reacting chamber 11A is isolated from the exhausting chamber 11B by the shatter 12. The parent substrate 30 on which the thick GaN film is formed is removed onto the supporter 40 in the heating chamber 11C without being exposing to air and laser beam is illuminated on the backside of the parent substrate 30 at a temperature of about 600 ℃ to 1000 ℃ to separate a single crystalline GaN film (thick GaN film) from the parent substrate 30. It should be noted that the thick GaN film and the parent substrate 30 are not cooled down to a room temperature.

Although the exhausting chamber 11B, as shown in Fig. 3, is positioned between the reacting chamber 11A and the heating chamber 11C, the reacting chamber 11A may be adjacent to the heating chamber 11C and the exhausting system 16 may be

directly connected to the reacting chamber 11A.

The hydride vapor phase epitaxy apparatus shown in Fig. 3 may be used to form group Ⅲ-N (nitrogen) compounds of single crystalline substrates, such as AlN, InN, GaInN, AlInN and AlGaInN, as well as the GaN single crystalline substrate, containers having Ga and In materials may be provided in the reacting chamber 11A and the hydrochloric acid and nitrogen gases flow into the reacting chamber 11A.

Figs. 4A to 4D illustrate a method for forming the GaN single crystalline substrate.

First, referring to Fig. 4A, the parent substrate 30 selected from one of an oxide substrate, such as sapphire (Al_2O_3) or spinel ($MgAl_2O_4$), and a silicon carbide substrate, such as SiC, is prepared and generally these parent substrates may have the lattice mismatch with the GaN materials and a different thermal expansion coefficient.

Next, referring to Fig. 4B, the thick GaN film 31 is formed on the parent substrate 30 in the hydride vapor phase epitaxy apparatus, as shown in Fig. 3, having the quartz boat in its reacting chamber 11A and the supporter 40 in its heating chamber 11C. The group Ⅲ elements such as Ga are positioned at a region which is maintained at a temperature of about 600 ℃ to 900 ℃ by the multi-step electric furnace 13. At this time, the parent substrate is maintained at a temperature of about 1000 ℃ to 1100 ℃. The reacting chamber 11A in which the quartz boat is placed is pumped out up to

about 10-3 torr, the reacting chamber 11A is gradually heated, and then the nitrogen gas injection into the reacting chamber 11A starts from about 600 ℃. When the reacting chamber 11A reaches to a temperature at which the thick GaN film is to be grown, the hydrochloric acid gas flows onto the Ga materials in the quartz boat and the ammonia gas is provided to the parent substrate 30 to form the thick GaN film 31 on the parent substrate 30 at a thickness of about 100 μm to 550 μm.

After forming the thick GaN film 31 on the parent substrate 30, the supply of the hydrochloric acid gas is broken off and the parent substrate 30 on which the thick GaN film 31 is formed is cooled with the supply of nitrogen and the ammonia gases until the temperature of the thick GaN film 31 reaches to a predetermined temperature range, e.g., about 600 ℃ to 1000 ℃.

Referring to Fig. 4C, when the temperature of the reacting chamber 11A reaches to 600 ℃ to 1000 ℃, the parent substrate 30 on which the thick GaN film 31 is formed is moved onto the supporter 40 in the heating chamber 11C. At this time, the temperature of supporter 40 is maintained at about 600 ℃ to 1000 ℃ and the bottom of the parent substrate 30 is turned over top so that the thick GaN film 31 is directly on the supporter 40. The turned upside of the parent substrate 30 is illuminated by laser beam. It should be noted that the thick GaN film 31 and the parent substrate 30 are not cooled down to a room temperature.

Referring to Fig. 4D, the parent substrate 30 is separated from the thick GaN film 31 by the high power laser beam. Nd:YAG laser beam, which has wavelength of 355 nm, power of about 500 mJ, pulse period of 10 to 20 Hz and pulse width of 5 to 6 ns, may be used. When this high power laser beam is illuminated on the parent substrate 30, the beam passes through the parent substrate 30 and is absorbed into the thick GaN film 31. If the thick GaN film 31 absorbs the high power laser beam, the GaN material, which is in a range of a few micrometers in thickness (dissolution area 32), are dissolved into gallium and nitrogen and the thick GaN film 31 is separated from the parent substrate 30 by this dissolution of the thick GaN film 31.

Since the single crystalline GaN substrate (the separated thick GaN film 31A has an uneven surface, the mechanical and chemical polishing using a diamond slurry is applied to the single crystalline GaN substrate 31A.

As apparent from the above, the present invention provides a high growing rate of the single crystalline nitride substrate without cracks caused by the lattice mismatch between other materials, by using the hydride vapor phase epitaxy method. Furthermore, the present invention provides stability and reliability of processing by effectively separating the single crystalline nitride substrate from the parent substrate by laser beam.

Although the preferred embodiments of the invention have been disclosed for illustrative purposes, those skilled in the

art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

Claims

1. An apparatus for forming a compound semiconductor substrate, the apparatus comprising:

a reacting chamber for forming a single crystalline film on a parent substrate;

a heating chamber connected to the reacting chamber within a processing channel, wherein the single crystalline film is separated from the parent substrate at a higher temperature than a room temperature; and

a supporter for supporting the single crystalline film and the parent substrate and maintaining the single crystalline film in a predetermined temperature.

2. The apparatus as recited in claim 1, wherein the apparatus is a hydride vapor phase epitaxy apparatus.

3. The apparatus as recited in claim 1, wherein the single crystalline film is a nitride.

4. The apparatus as recited in claim 1, wherein the predetermined temperature is in a range of 600 ℃ to 1000 ℃.

5. The apparatus as recited in claim 1 or 2, wherein the apparatus further comprises an exhausting chamber positioned between the reacting chamber and the heating chamber, and wherein each of reacting, exhausting and heating chambers is

isolated from each other by shutters.

6. A method for forming a compound semiconductor substrate, the method comprising the steps of:

a) preparing a parent substrate;

b) forming a single crystalline film on the parent substrate in a reacting chamber;

c) maintaining the single crystalline film in a predetermined temperature which is higher than a room temperature; and

d) illuminating laser beam on a backside of the parent substrate and separating the single crystalline film from the parent substrate.

7. The method as recited in claim 6, wherein the single crystalline film is a nitride.

8. The method as recited in claim 6, further comprising the steps of:

e) heating the parent substrate up to a predetermined temperature which is higher than a room temperature; and

f) moving onto a supporter the parent substrate on which the single crystalline film is formed, wherein the supporter is positioned in a heating chamber which is connected to the reacting chamber within a processing channel.

9. The method as recited in claim 6 to 8, wherein the

parent substrate is selected from one of sapphire (Al_2O_3), spinel ($MgAl_2O_4$) or silicon carbide (SiC) and the single crystalline film is a nitride.

10. The method as recited in claim 9, wherein the single crystalline film is formed by a hydride vapor phase epitaxy.

11. The method as recited in claim 9, wherein the step b) comprises the steps of:

a1) positioning a material selected from a group Ⅲ at a first temperature region of 600 ℃ to 900 ℃ in the reacting chamber and positioning the parent substrate at a second temperature region of 1000 ℃ to 1100 ℃ in the reacting chamber;

a2) injecting a nitrogen gas into the reacting chamber;

a3) injecting a hydrochloric acid gas into the reacting chamber; and

a4) injecting an ammonia gas into the reacting chamber.

12. The method as recited in claim 11, wherein the parent substrate is heated up to 600 ℃ to 1000 ℃.

Abstract

The present invention relates to an apparatus and a method for forming a single crystalline nitride substrate, and more particularly, to an apparatus and a method for preventing cracks from being generated in a single crystalline nitride substrate. A method for forming a compound semiconductor substrate includes the steps of: a) preparing a parent substrate; b) forming a single crystalline film on the parent substrate in a reacting chamber; c) maintaining the single crystalline film in a predetermined temperature which is higher than a room temperature; and d) illuminating laser beam on a backside of the parent substrate and separating the single crystalline film from the parent substrate. Accordingly, the present invention provides a large single crystalline nitride substrate, by preventing cracks caused by the lattice mismatch with the parent substrate.

FIG. 1

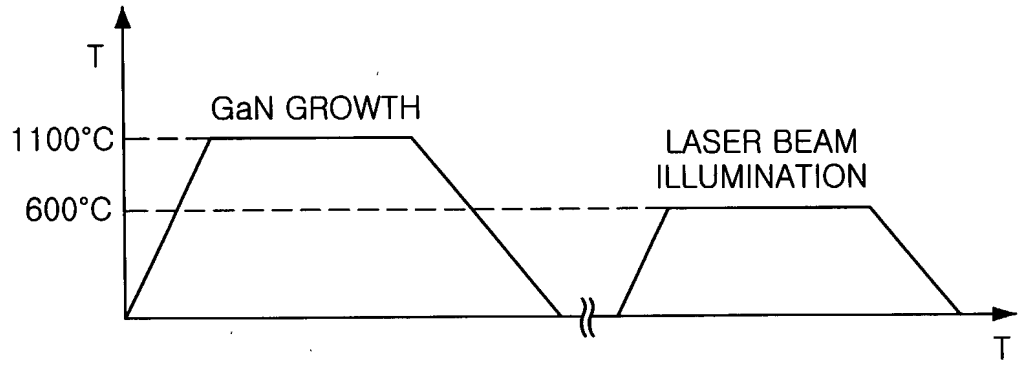

T
GaN GROWTH
1100°C
600°C
LASER BEAM
ILLUMINATION
T

FIG. 2

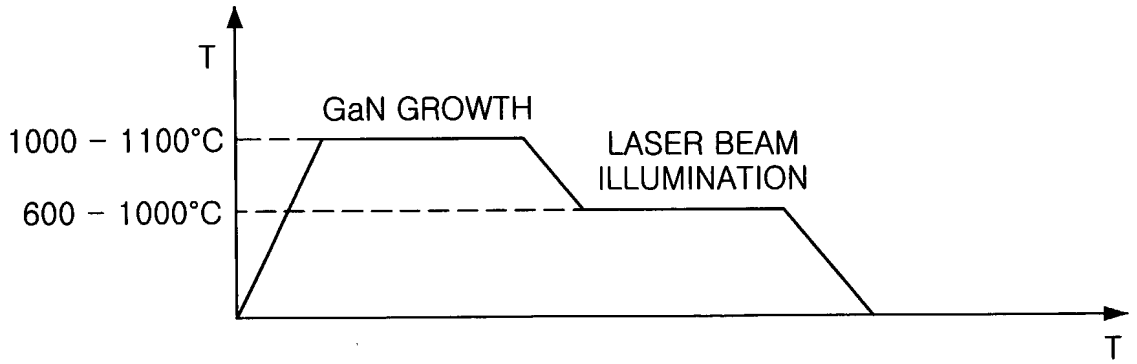

T
GaN GROWTH
1000 – 1100°C
600 – 1000°C
LASER BEAM
ILLUMINATION
T

FIG. 3

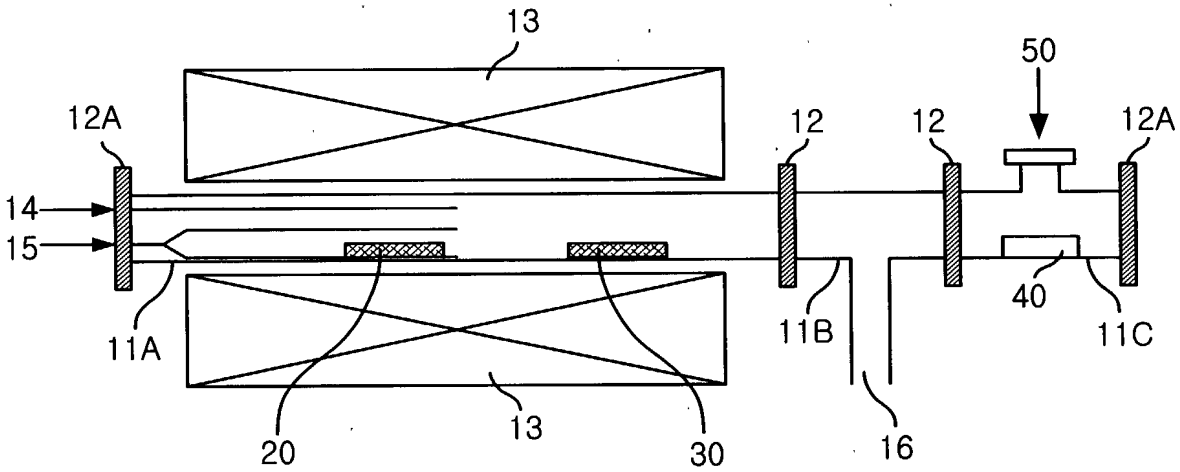


FIG. 4A

FIG. 4B

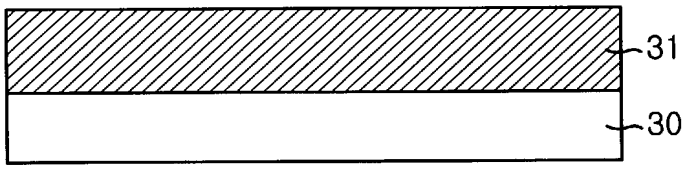


FIG. 4C

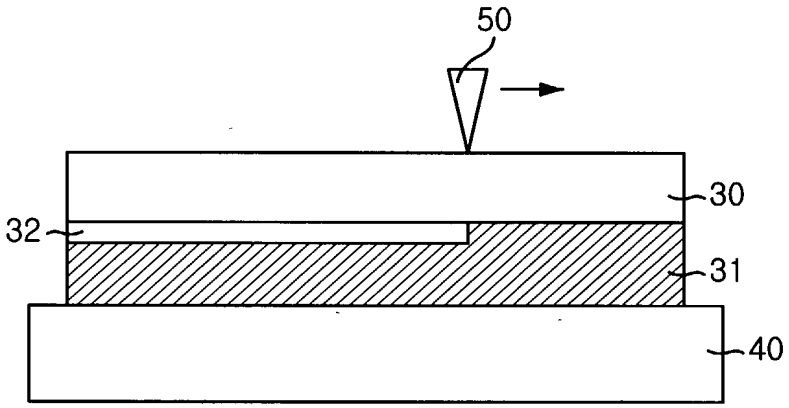
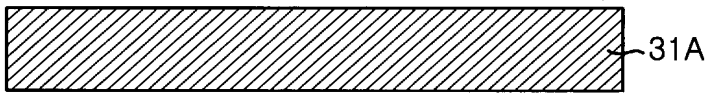


FIG. 4D



BAKER BOTTS L.L.P.
FILE NO.:

COMBINED DECLARATION AND POWER OF ATTORNEY

(Original, Design, National Stage of PCT, Divisional, Continuation or C-I-P Application)

As a below named inventor, I hereby declare that:
My residence, post office address and citizenship are as stated below next to my name; I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:
APPARATUS AND METHOD FOR FORMING SINGLE CRYSTALLINE NITRIDE SUBSTRATE USING HYDRIDE VAPOR PHASE EPITAXY AND LASER BEAM

This declaration is of the following type:

[ ] original
[ ] design
[x] national stage of PCT
[ ] divisional
[ ] continuation
[ ] continuation-in-part (C-I-P)

the specification of which: *(complete (a), (b), or (c))*

(a) [ ] is attached hereto.
(b) [ ] was filed on_____as Application Serial No._____and was amended on _____(if applicable).
(c) [x] was described and claimed in PCT International Application No. PCT/KR00/00935 filed on August 21, 2000 and was amended on December 10, 2001 (if applicable).

Acknowledgement of Review of Papers and Duty of Candor

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of the subject matter claimed in this application in accordance with Title 37, Code of Federal Regulation § 1.56.

[ ] In compliance with this duty there is attached an information disclosure statement. 37 CFR 1.98.

Priority Claim

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(b) of any foreign application(s) for patent or inventor's certificate or of any PCT International Application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT International Application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application on which priority is claimed

(complete (d) or (e))

(d) [ ] no such applications have been filed.
(e) [x] such applications have been filed as follows:

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PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS(6 MONTHS FOR DESIGN) PRIOR TO SAID APPLICATION				
COUNTRY	APPLICATION NO.	DATE OF FILING (day, month, year)	DATA OF ISSUE (day, month, year)	PRIORITY CLAIMED UNDER 35 USC119
Republic of Korea	1999-41892	30/09/1999		[x] YES NO [ ]
				[ ] YES NO [ ]
				[ ] YES NO [ ]
ALL FOREIGN APPLICATION[S], IF ANY, FILED MORE THAN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO SAID APPLICATION				
				[ ] YES NO [ ]
				[ ] YES NO [ ]
				[ ] YES NO [ ]

Claim for Benefit of Prior U.S. Provisional Application(s)

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

Provisional Application Number	Filing Date

Claim for Benefit of Earlier U.S./PCT Application(s) under 35 U.S.C. 120

(complete this part only if this is a divisional, continuation or C-I-P application)

I here by claim the benefit under Title 35, United States Code, § 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior application(s) in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose information as defined in Title 37, Code of Federal Regulations, § 1.56 which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

(Application Serial No.) (Filling Date) (Status(patented, pending, abandoned)

(Application Serial No.) (Filling Date) (Status(patented, pending, abandoned)

Power of Attorney

19 As a named inventor, I hereby appoint Dana M, Raymond, Reg. No. 18,540; Frederick C. Carver, Ref. No. 17,021; Francis J. Hone, Reg. No. 18,662; Joseph D. Garon, Reg. No. 20,420; Arthur S. Tenser, Reg. No. 18,839; Ronald B. Hildreth, Reg. No. 19,498; Thomas R. Nesbitt, Jr., Reg. No. 22, 075; Robert Neuner, Reg. No. 24,316; Richard G. Berkley, Reg. No. 25,465; Richard S. Clark, Reg. No. 26,154; Bradley B. Geist, Reg. No. 27,551; James J. Maune, Reg. No. 26,946; John D. Murnane, Reg. No. 29,836; Henry Tang, Reg. No. 29,705; Robert C. Scheinfeld, Reg. No. 31,300; John A. Fogarty, Jr., Reg. No. 22,348; Louis S. Sorell, Reg. No. 32,439; Rochelle K. Seide Reg. No. 32,300; Gary M. Butter, Reg. NO. 33,841; Marta E. Delsignore, Reg. No. 32,689; and Lisa B. Kole, Reg. No. 35,225 of the firm of BAKER BOTTS L.L.P., with offices at 30 Rockefeller Plaza, New York, New York 10112, as attorneys to prosecute this application and to transact all business in the Patent ad Trademark Office connected therewith

SEND CORRESPONDENCE TO:	DIRECT TELEPHONE CALLS TO:
~~BAKER BOTTS L.L.~~P. ~~30 ROCKEFELLER PLAZA, NEW YORK, N.Y. 10112~~ ~~CUSTOMER NUMBER: 21003~~	BAKER BOTTS L.L.P. (212)705-5000

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both,

BAKER BOTTS L.L.P.
FILE NO.:

under Section 1001 of Title 18 of the United States Code and that such willful false statement may jeopardize the validity of the application or any patent issued thereon.

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DATE MARCH 22, 2002	SIGNATURE OF INVENTOR B. C. Kim		
FULL NAME OF SECOND JOINT INVENTOR, IF ANY	LAST NAME	FIRST NAME	MIDDLE NAME
RESIDENCE & CITIZENSHIP	CITY	STATE or FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
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DATE	SIGNATURE OF INVENTOR		
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POST OFFICE ADDRESS	POST OFFCE ADDRESS	CITY	STATE or COUNTRY / ZIP CODE
DATE	SIGNATURE OF INVENTOR		
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RESIDENCE & CITIZENSHIP	CITY	STATE or FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
POST OFFICE ADDRESS	POST OFFCE ADDRESS	CITY	STATE or COUNTRY / ZIP CODE
DATE	SIGNATURE OF INVENTOR		
FULL NAME OF FIFTH JOINT INVENTOR, IF ANY	LAST NAME	FIRST NAME	MIDDLE NAME
RESIDENCE & CITIZENSHIP	CITY	STATE or FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
POST OFFICE ADDRESS	POST OFFCE ADDRESS	CITY	STATE or COUNTRY / ZIP CODE
DATE	SIGNATURE OF INVENTOR		
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RESIDENCE & CITIZENSHIP	CITY	STATE or FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
POST OFFICE ADDRESS	POST OFFCE ADDRESS	CITY	STATE or COUNTRY / ZIP CODE
DATE	SIGNATURE OF INVENTOR		

Check proper box(es) for any added page(s) forming a part of this declaration

[ ] Signature for ninth and subsequent joint inventors. Number of pages added_____.

[ ] Signature by administrator(trix), executor(trix) or legal representative for deceased or incapacitated inventor. Number of pages added _____.

[ ] Signature for inventor who refuses to sign, or cannot be reached, by person authorized under 37 CFR 1.47. Number of pages added_____.

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